

condemns the muscle to rest. The stimuli then start from the nerve-cell, to them the muscles react by doing work, and they are conveyed to the muscles through the continuation of the cell which the nerve-fibre presents. We need not yet trouble ourselves how the excitation of the nerve-cell arises, whether through external—sensory—stimuli, or through an enigmatical psychic act, or through chemical influences; certain it is that these were, before the division of the nerve, the sole impulse to the muscle's movements. But what the muscles lack we can supply artificially, and more; we can put the nerve-remnant in such manifold states of excitement as it never before experienced from its cell-body, so that the muscle is compelled to undergo many kinds of movement quite new to it, and we can attain the same result by direct stimulation of the muscle.

In the circle of these experiences arose the controversy, not yet quite ended,¹ as to muscular irritability; properly, the question whether it was, in general, possible to stimulate anything artificially that is not nerve—that is, to set free the activity peculiar to a non-nervous structure by the means at our command.

Haller, who was the first to occupy himself minutely with the stimulation of muscle, and introduced the term irritability, decided, but only incidentally and by the way, that the stimulus could strike also the ramifications of the nerve in the muscle, and he was far from interesting himself in the question in the modern sense, or from suspecting the point of view from which the independent irritability of muscle would later on be questioned. We ought not to blame him much for the latter, since even to-day it is not easy to understand the motives of an opposition now continued for more than a century. At the outset, if I am not mistaken, the teaching of the Animistic, or, as it might now be called, the Neuristic school, led to the conception that not only the excitation and regulation of the various functions, but the actual endowment of the several tissues with their respective activities, was the work of that everywhere predominant and distinctly animal contrivance, the nervous system.

In connection with this, there seems to have arisen the view of the ubiquity of nerves—that is, of so fine a penetration of the parts with nerve radiations, that, especially in muscle, not the smallest particle free from nerve could be demonstrated, a view which, on the strength of microscopic research, is coming up again at the present day in a constantly new dress, and finds energetic adherents,² but, as we shall see, to be refuted, especially by experiment. If we disregard this, we shall find the tendency to consider only nerves as excitable, in some degree founded on the differentiation which transferred automatism to the nervous matter, robbing all the remaining tissues of irritability, so that they only retained the faculty of reacting to the stimulated nerve with which they were bound up. This was as much as saying it was impossible artificially to replace the nervous stimulus, or that, if we did succeed, we were strictly imitating it, in which case, indeed, we should have come unawares upon the solution of the problem of motor innervation. Against such arguments it availed nothing to point out the excitability of nerveless sarcodæ, as was often done in favour of irritability; for, just as it was formerly useless, because the real genetic connection of sarcodæ and muscle was not known, so to-day it would have to be rejected, because automatic protoplasm can also be correctly considered nervous.

A non-irritable muscle would strike us as strange enough, and, against all expectation, different from the nerve, when we consider that the nerve-fibre, although incapable of being affected by all the natural stimuli which excite its ganglion-cells, free, that is, from automatism, is artificially excitable at every spot by the most different agents. However, we have no further need of such considerations, since the question of irritability lies within a region where, instead of speculation, observation and experiment have become decisive.

¹ Cf. J. Rosenthal, "Allgemeine Physiologie der Muskeln und Nerven," Leipzig, 1877, p. 255.

² J. Gerlach, "Ueber des Verhalten der Nerven in den quergestreiften Muskelfäden der Wirbelthiere," *Erangen Phys. Med. Soc. Sitzber.*, 1873. "Das Verhältniss der Nerven zu den wirklichen Muskeln der Wirbelthiere," Leipzig, 1874. "Ueber das Verhältniss der nervösen und kontraktile Substanz der quergestreiften Muskeln," *Archiv Mikrosk. Anat.*, vol. xiii. p. 399. A. Foettinger, "Sur les terminaisons des nerfs dans les muscles des insectes," *Archives de Biol.*, vol. i., 1880. Engelmann, *Pflüger Archiv*, vol. vii., 1873, p. 47; vol. xi., 1875, p. 463; vol. xxvi. p. 531. In these publications it is sought to prove that the motor nerves pass either into the interstitial nucleated substance of the muscle (therefore into the sarcoglia) or into the layers of the "Nebenseiben." This latter view is opposed by, among others, A. Rollett, in his thoroughgoing exposition of the structure of muscle (Vienna, *Denkschriften der k. Akad.*, vol. xlix. p. 29), and W. Kühne (*Zeitschr. f. Biol.*, vol. xxiii. p. 1.

As a matter of fact, the older statements, long considered a good basis for opposing irritability, are incorrect, as, for instance, that an excised piece of muscle in which no nerves could be seen with the lens did not twitch on stimulating it.

We can show you a little piece, 3 millimetres long, from the end of the sartorius muscle of the frog, in which the best microscope discovers no traces of nerves, easily made recognizable by osmium-gold staining (Fig. 1). Such a piece, transversely cut off, twitches, as we know, at each effective muscular stimulus. Pieces which can be obtained free from nerves from many other muscles behave in the same way, as, for instance, pieces from the delicate muscles of the pectoral skin of a frog (Fig. 2).

Further, the assertion was incorrect that everything that excited the nerve made the muscle twitch, and *vice versa*; for we see here a sartorius suspended in ammonia vapour, contracting



FIG. 1.

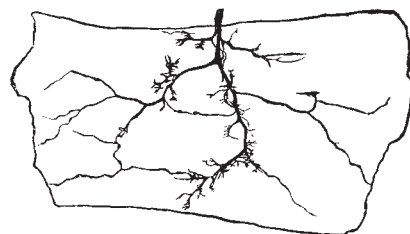


FIG. 2.

powerfully, while a nerve entirely submerged in liquid ammonia appears wholly unstimulated, for it does not rouse the thigh muscles from their repose.

Conversely, we see a thigh whose nerve dips into glycerine in maximal contraction, and, on the other hand, a muscle in contact at its excitable end with the same glycerine remains at rest, yet it twitches if I dip it in up to its nerve-bearing tracts.²

These are old experiments,³ and it is admitted they have overthrown the earlier opinion. But they have not been deemed sufficient to prove muscular irritability, because the ultimate endings of the nerves might have an irritability other than that of their stems. This is the only objection still raised. One could wish no other were conceivable, for this one admits of refutation.

(To be continued.)

THE HEMENWAY EXPEDITION IN ARIZONA.⁴

DR. JACOB L. WORTMAN, of the United States Army Medical Museum, has just returned from Arizona, where he has spent the winter and spring attached to the Hemenway South-Western Archaeological Expedition under the direction of Frank Hamilton Cushing, which was mentioned in the March number of the *Naturalist*, and he confirms the importance as well as the genuineness of the discoveries of Mr. Cushing. The Expedition is thoroughly equipped and well organized, and its investigations have been conducted in a vigorous and scientific manner, with special reference to the many details which go to make collections of this character of value to the scientific student. Not only have the ruins been carefully surveyed and mapped, but each specimen has been labelled with great care, in

¹ The drawings, Figs. 1, 2, 3, 5, 8, are taken from the papers of Dr. K. Mays, "Histophysiologische Untersuchungen über die Verbreitung der Nerven in den Muskeln" (*Zeitschr. Biol.*, vol. xx. p. 449), and "Ueber Nervenfaservertheilungen in den Nervenstämmen der Froschmuskeln" (*Zeitschr. Biol.*, vol. xxii. p. 354); Figs. 9-13 are from the author's papers in *Zeitschr. Biol.*, vol. xxiii. pp. 1-148, Plates A-Q.

² The experiments were performed during the lecture by projecting on the wall images of the preparations enlarged some thirty times.

³ Kühne, "Ueber direkte und indirekte Muskelreizung mittelst chemischer Agentien," *Müller's Archiv. f. Anat.*, 1859, p. 213.

⁴ Reprinted from the *American Naturalist*, June 1888. The writer is Mr. Thomas Wilson, of the Smithsonian Institution.

such a manner as to indicate exactly where found, together with all such other facts in connection with it as will be of use to the student.

The Expedition has for its object the study of the ancient civilization of the south-west, and if the results of the first year's work can be taken as an index of what it will accomplish, we may confidently look for a solution of this perplexing question. Already a large and valuable collection illustrative of the culture of these prehistoric people has been secured, and it is a matter of congratulation that it has been so collected that the scientific student can get all out of it that it can be made to tell.

Mr. Cushing's ethnological training has been in such a direction as to give him a peculiar fitness for the position which he occupies, having spent six years or more in studying the social institutions, customs, habits, religion, and language of the modern Pueblo Indians, and this thorough knowledge of these is indispensable to the proper interpretation of the facts gathered by the Expedition. The anthropological work is in charge of Dr. Herman Ten Kate, a native of Holland, son of the distinguished artist of that name. Dr. J. L. Wortman, the Anatomist of the Army Medical Museum of Washington, is his assistant. Mr. Adolph Bandelier, whose knowledge of the early Spanish and Mexican records is well known, is connected with the Expedition as historian. Mr. Chas. A. Garlick is the civil engineer and topographer. Mr. Fred. Hodge is the draughtsman and secretary, while Mr. Yates is the photographer. Mrs. Cushing and her sister, Miss Margaret Magill, are also members of the party, and have rendered important aid in the classification and care of the specimens. Miss Magill's artistic talents have been of special service to the Expedition by reason of her clever sketches and drawings of the specimens *in situ*.

The locality in which explorations have so far been conducted comprises the Gila and Salt River Valleys, situated for the most part in South-Western Arizona. They are fertile tracts of large extent, and there can be little doubt that they were once occupied by a thrifty and prosperous people, whose history remains unwritten. The Rio Salado (Salt River) is the principal tributary of the Gila, and affords abundant water to irrigate its valley, a tract including a half a million acres, or more. The land for the most part is covered with cactus, sage brush, grease wood, and mesquite trees, but when cleared and brought under irrigation is made to produce abundantly almost any and all the crops of civilized husbandry. Fruits and cereals grow in profusion, and the land is said to be well adapted to the growth of cotton and tobacco. The land rises from the river at a gentle slope, a fact which is of great importance to a system of irrigation. At the upper or north-western end of the valley, however, the river is bordered upon the south by a mesa which slopes away to the Gila, no mountains intervening between the streams at this point. Water brought from the Salt River upon this mesa can be made to flow a distance of twenty miles to the south, or into the Gila, and will irrigate a tract many miles in extent. This these ancient people did, and, scattered over this plain from the Salt to the Gila are to be found the ruins of their villages, towns, and cities, long since crumbled into dust, and now overgrown with a thick mesquite forest.

Their houses were for the most part built along the main irrigating canals, and are now indicated by irregular truncated mounds, of various dimensions, thickly strewn with fragments of broken pottery. Excavating these mounds, the foundations or ground plans of the buildings were discovered. Some of them were large, often several hundred feet square, and, according to Mr. Cushing, three or four stories in height. They were constructed usually of adobe bricks, but in some instances they inclosed the adobe between rows of upright posts wattled with cane or willow. Each house would contain from two to five hundred rooms, and is thought by Mr. Cushing to have been the house of a clan. A considerable grouping of the communal houses constitutes what Mr. Cushing has called the cities of Los Muertos, Los Hornos, Los Guanacas, Los Pueblitas, Los Acequias, &c. They are not built with the regularity of our modern cities. Los Muertos (the city of the dead) can be traced for three or four miles, and includes some forty or fifty of these great communal structures that have been so far unearthed, but if systematic search be continued double or quadruple this number will probably be found.

A characteristic feature of each of these cities, and one which probably led Mr. Cushing to designate them as such, is a ruin of much greater dimensions than any of the rest, which is invariably surrounded by a strong outside wall, inclosing a

considerable space or yard. This inclosed space around the large building or temple is supposed to have been for the purpose of protection in times of war, when pressed by an enemy, and the large building itself served not only as a store-house for a reserve supply of provisions, but also, if we are to judge from the remains and implements, was the abode of the ruler or chief priest of the people of the town.

While no accurate computations have been attempted, it is supposed, taking into consideration the number of towns or cities known to have existed in the Gila and Salt River Valleys that the population could not have been less than two hundred thousand. There is every reason to believe that these places were not successively, but simultaneously occupied, especially when we remember that they constructed large irrigating canals for a distance of fifteen or twenty miles, which with their rude implements must have been a gigantic undertaking. Their irrigating system was extensive and complete, and covered almost, if not quite, all the cultivable parts of the two valleys. The present inhabitants of the soil have taken advantage of these ancient waterways, constructed at such expenditure of prehistoric labour, and they now run many of their irrigating canals in these ditches. These ancient canals were constructed with care. A cross-section exhibits a series of terraces widening towards the top, so that a large or small quantity of water could be accommodated and a good depth secured. After the canals were dug they were puddled and then burnt, probably by filling them with brush and then setting it on fire, so that they almost equalled terra-cotta in durability. Mr. Cushing is of opinion that they were not used for irrigation alone, but for navigation as well. There are indications that they used rafts made of reeds (balsas) for navigating these canals, and this appears more probable from the heavy materials that have been brought from a distance. It seems certain that they floated the pine timber used in their building operations down the Salt and Gila Rivers from the distant mountains: it is too much to suppose that they carried this material upon their backs for a distance of a hundred miles.

The burial customs of these people were peculiar, and consisted of two methods, viz. cremation and interment. In the case of the priestly class the body was wrapped in cotton cloths and deposited beneath the floor of the house. Generally the bodies were laid along the east wall of the building, with head to the east, although this custom was not invariable. When a person of this class died, a grave was dug in the floor, a foot and a half or two feet deep, and the body placed therein; it was then covered with adobe mud and packed firmly around the corpse. When this covering dried, and the soft parts and wrappings disappeared, the skeleton would be found inclosed in a rude sort of sarcophagus. In numerous instances, two, and more rarely three, skeletons were found in one grave. In all such cases of double or triple burial the skeletons indicate that it was male and female, or one male and two females. Buried with each cadaver was a food vessel and a water jar, and sometimes several of each, often highly decorated. That they were wrapped in cloths, presumably of cotton, is evident from the impressions of the cloth made upon the soft adobe covering. Fragments of this material were found and preserved, notwithstanding its decomposed condition.

Connected with each communal structure is what Mr. Cushing aptly terms a pyral mound, since the bodies of the common class were burned and their possessions destroyed upon this spot. The ashes and fragments of the charred bones were collected and placed in a burial urn, which had been previously "killed," and the whole buried in close proximity to the spot. The accumulations of this charred and fragmentary material now make mounds of sizable dimensions, which in itself would indicate a long period of occupancy. In the case of the pyral burials everything was broken and destroyed, while in the priestly burials the accompaniments were always whole. In one case of the priestly burials not only were the usual accompaniments present, but a quantity of arrow-points, spear-heads, and a large stone knife, together with numerous turquoise ornaments and materials for inlaying, were found deposited in the grave. This individual Mr. Cushing identified from his paraphernalia as belonging in all probability to the priesthood of some war order, and this seems more probable when we come to examine the skeleton, for he had sustained a fracture of the arm, and one knee was stiff from ankylosis, no doubt the scars of hard-fought battles.

Of the priestly burials something like four or five hundred were unearthed in the various towns, while many more of the

cremated remains were found in the vicinity of the pyral mounds. The skeletons, as a rule, were so frail that comparatively few could be preserved. Of the whole number about one hundred good skulls, and probably fifty tolerably complete skeletons, were collected. These were so frail that Dr. Wortman was compelled to use a goodly supply of shellac varnish to keep them from falling to dust. Silicate of soda was tried, but it was not found so good as the ordinary shellac dissolved in alcohol.

The objects which go to make up the collection are various, and consist of those of ornament and utility. Numerous shell carvings, some of which had been beautifully inlaid with turquoise, were found, while a very few copper ornaments in the shape of bells and ear-rings were also dug up. Their tools consist almost entirely of stone, and were, for the most part, polished, though such implements as potters' stones, rasps, mauls, metates, &c., were never polished. Their stone axes and hatchets are of the ordinary pattern, and are generally well polished; they are of various sizes and shapes, and some of them were no doubt used as picks in digging up the hard cement and gravel in the construction of their irrigating canals. Stone hoes, knives, and arrow-heads were also found in abundance.

The collection of pottery is large, and, according to Mr. Cushing, resembles that of Zuni manufacture more than any other people. It is often highly decorated with quaint and unique patterns, in various colours, and some fragments exhibited a fine glaze, which indicates a high state of the ceramic art.

That they were acquainted with metals there can be but little doubt, although they do not appear to have made use of it except in the way of ornament. Some places in the neighbouring mountains seemed to indicate that they mined for ore, which they smelted in crude ovens. Whether this was copper or the precious metals is now difficult to determine, but that they were accustomed to bring these ovens or furnaces to a very high heat is indicated by the slag in their immediate vicinity.

It is perhaps premature to attempt to decide who these people were, to whom they were related, and what became of them. I think it fairly settled by these discoveries that they were the ancestors of the modern Pueblos. Whether or not they were in any way connected with the ancient people of Mexico and Yucatan the future alone can decide. It seems certain, however, that one part of them went north to found the later Pueblo civilizations which are now represented by the Zuñis of to-day.

If historical evidence is worth anything, and if we can trust the ordinary evidences of archaeology, then these ruins are beyond question pre-Columbian, and may be as much as a thousand years old.

Mr. Cushing's final Report will be awaited with interest by all who are in any way interested in the subject. The archaeological specimens have been shipped to Salem, and the skeletons will go to the Army Medical Museum in Washington.

SELF-REPRODUCING FOOD FOR YOUNG FISH.

IN a very interesting Report of the United States Consul at Marseilles on the above subject, he says that every person interested in the artificial propagation of fish, particularly those of the genus *Salmonidae*, knows the great care which is necessary to carry the young fry through the period immediately following the absorption of the umbilical sac, and to bring them to such a stage of maturity that they can be safely turned loose in open ponds and streams to shift for themselves. The mere hatching of the eggs presents no difficulty, but with the commencement of artificial nutrition the serious part of the work begins, and it is usually only a small percentage of the swarms which are hatched that reach the maturity of yearlings. During the intervening months it has been customary to feed the young fish on curdled milk, coagulated blood, finely hashed meat and liver, grated yolk of eggs, macerated brains of animals, &c., the preparation of which, and the constant feeding of the little creatures, involves constant and costly labour. Besides, none of these forms of nutriment have been found entirely satisfactory; they are artificial, and different from the living organic food which Nature provides. A plan invented by Mr. F. Lugrin, of Geneva, and practised since 1884 with the greatest success in the piscicultural establishment at Gremaz, in the province of Ain, in Eastern France, seems to overcome all these difficulties. The apparatus at Gremaz occupies a gently-sloping piece of ground, about six acres in extent, watered by three springs, which collectively

yield about 500 gallons of water a minute. The tanks are about 120 feet long, 12 feet wide, and 5 feet deep. On account of the gravelly nature of the soil, the walls and bottoms of some of the tanks are lined with cement. The tanks are divided by sliding gates of wire gauze sufficiently fine to prevent the passage of the fry. Mr. Lugrin spreads upon the bottom of these tanks a material impregnated with the elements necessary to produce spontaneously a limitless number of *Daphnia*, *Cyclops*, *Limna*, as well as larvæ of various *Ephemera* which form the natural aliment of trout and other *Salmonidae*. This producing material is of trifling cost. The water in the tanks, which is from 2 to 3 feet deep, is left undisturbed for a few weeks, and is then found to be peopled with myriads of the species above named. With a fairly abundant propagation of these organisms, 20,000 young fry and 3000 fish one year old can subsist and thrive for a whole month in a tank of the size of one of those at Gremaz. These 23,000 fish and fry will eat from 600 to 800 pounds in a month, and each tank at Gremaz will produce from 650 to 900 pounds of *crevettes* (freshwater shrimps), to say nothing of the myriads of other species which are produced at the same time. Trout raised by this method have the flavour and firmness of wild fish. One great advantage of Mr. Lugrin's system is, that once a tank is prepared it is permanently productive.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The lecture-lists for this term contain no considerable innovations in the physical and chemical teaching. The usual systematic courses are to be given at the University Museum, and at Balliol, Christ Church, and Trinity. We may notice especially the following lectures:—

Prof. Pritchard, Recent Speculations on the Structure of the Stellar Universe, Spherical Astronomy, and the Theory of Errors; Prof. Price, Optics; Mr. Walker, Double Refraction treated Mathematically; Mr. Baynes, Theory of Gases, and Practical Electrical Measurements; Prof. Odling, 5-Carbon and 6-Carbon Compounds; Mr. Vernon Harcourt, Volumetric Analysis.

In the Biological Departments two new Professors have just entered on their offices. Prof. Green is giving two courses of lectures on Geology, and improving the Museum collections, and Prof. Vines has begun a systematic course of Elementary Botany. The Morphological Laboratory is in charge of Dr. Hickson and Mr. Latter; and Mr. Mitchell lectures on the Geographical Distribution of Animals. Prof. Burdon-Sanderson is lecturing on Elementary Physiology, and Mr. Gotch has a more advanced course. Dr. Tylor's subject this term is Race, Language, and Civilization.

An important statute has just past Convocation, which introduces the biological sciences into the Pass Examinations of the University for the B.A. degree. It is expected that the change will be of great use, especially to medical students, who cannot afford the time required to read for an Honour Examination in Natural Science.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 15.—M. Des Cloizeaux in the chair.—On the deformation of the images of stars seen by reflection on the surface of the sea, by M. C. Wolf. An attempt is here made to calculate the extent of this deformation, attention to which has lately been drawn by M. Riccò. The calculation shows that the difference in the angular heights of the object and its image increases towards the zenith, at first rapidly, then slowly, attaining its maximum at the zenith, for which it is double the depression of the horizon. A luminous band stretching from the apparent horizon to the zenith of the observer, and subtending an angle of $90^{\circ} 19' 2''$, would give an image terminating at the nadir, and with an angular extent of not more than $90^{\circ} - 19' 2''$.—On the latent colours of bodies, by M. G. Govi. The experiments here described with the bi-iodide of mercury, minium, and some other substances exposed to the light of the incandescent vapour of sodium—that is, the nearly pure yellow light D—tend to show that ordinary diffused or transmitted light does not give us the true colour of bodies. To obtain this true, but invisible or latent colour, a special process of illumination is